EXh. 1

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(54) Controlling operation of cooking apparatus

(57) A method of cooking different volumes of food, eg. rice, in a cooking apparatus includes the steps of heating the food to a prescribed set temperature in the cooking apparatus, stopping the heating for a first predetermined period for losing heat from the food, applying heat to the food for a second prescribed period, detecting the actual temperature of the food, measuring a period elapsed until the detecting time, and computing a value corresponding to the thermal capacity of the food in the cooking apparatus from the detected temperature and the elapsed period, and thereafter cooking the food for a period corresponding to the computed value.

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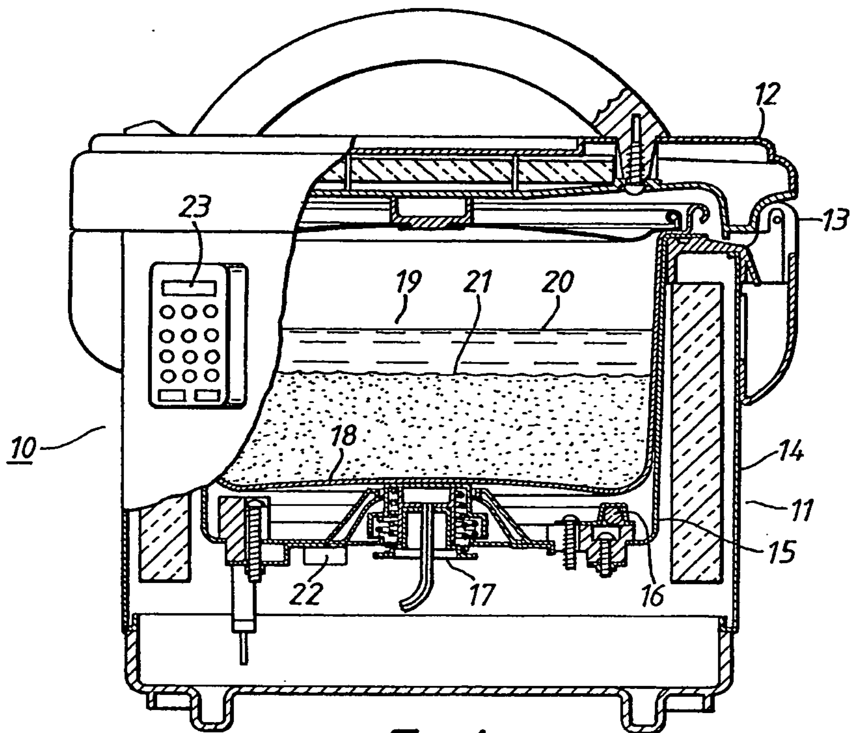
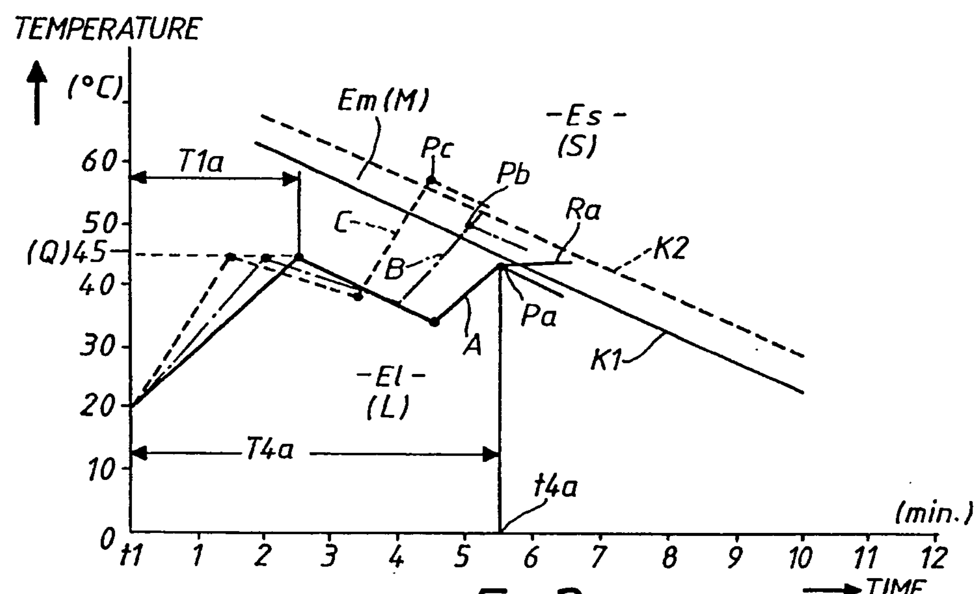
GB 2 191 024 A



12
13
23
19
21
20
10
18
14
11
15
22
17
16

FIG. 1.



TEMPERATURE
(°C)
60
50
(Q)45
40
30
20
10
0
T1a
Em(M)
-Es-
(S)
Pc
Pb
Ra
C
B
K2
Pa
A
K1
-El-
(L)
T4a
t4a
(min.)
t1
1
2
3
4
5
6
7
8
9
10
11
12
TIME

FIG. 2.

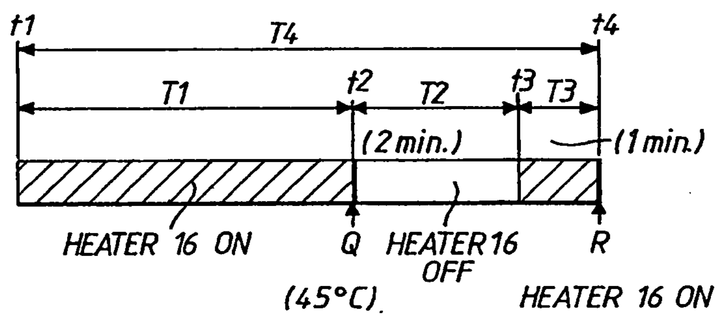

t1
T4
t4
T1
t2
T2
t3
T3
(2 min.)
(1 min.)
HEATER 16 ON
Q
HEATER 16
OFF
R
(45°C)
HEATER 16 ON

FIG.3.

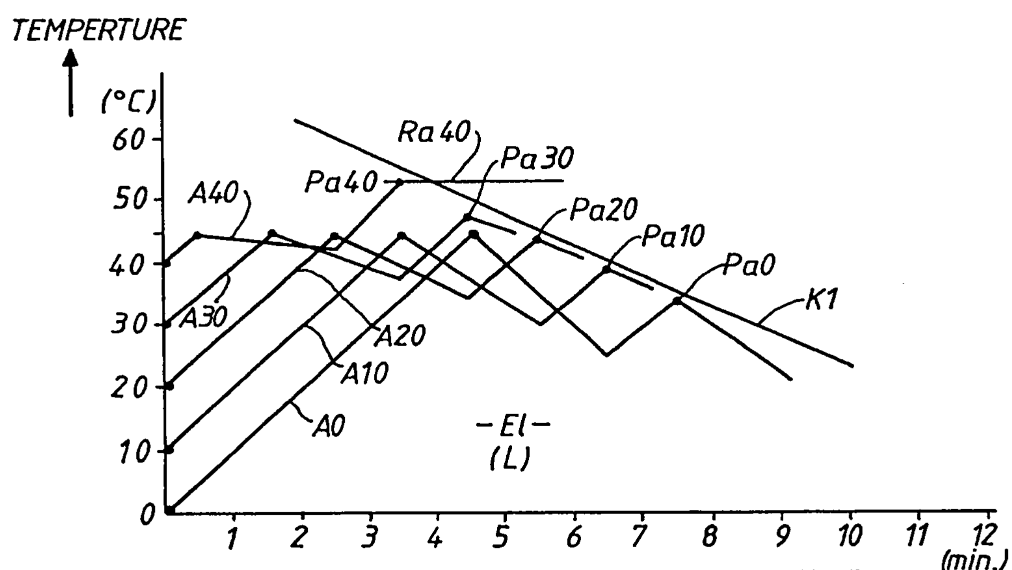

TEMPERTURE
(°C)
60
50
40
30
20
10
0
Ra40
Pa30
Pa40
A40
Pa20
Pa10
Pa0
K1
A30
A20
A10
A0
-El-
(L)
1
2
3
4
5
6
7
8
9
10
11
12
(min.)
TIME

FIG.4.

2191024

3/4

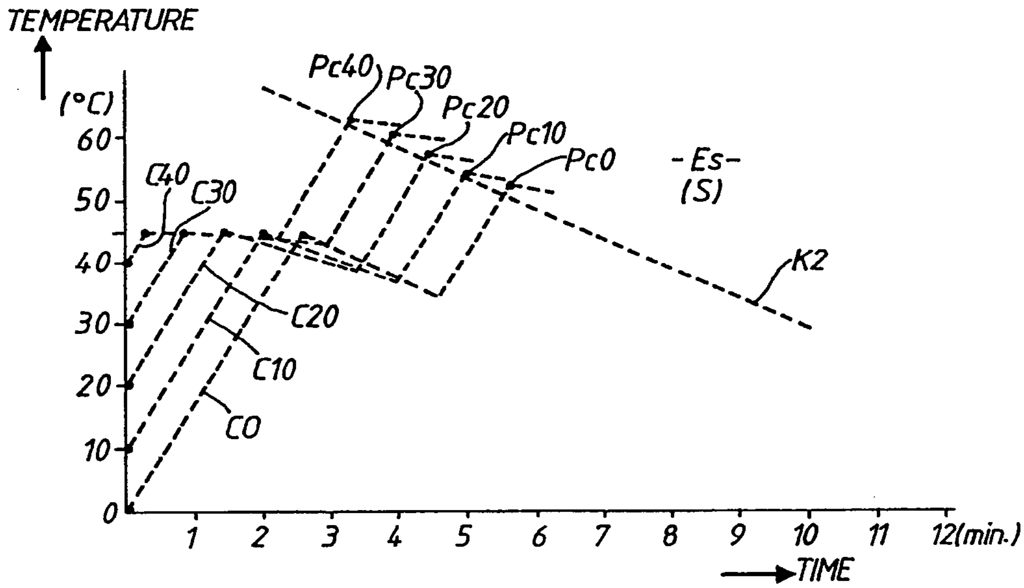


FIG.5.

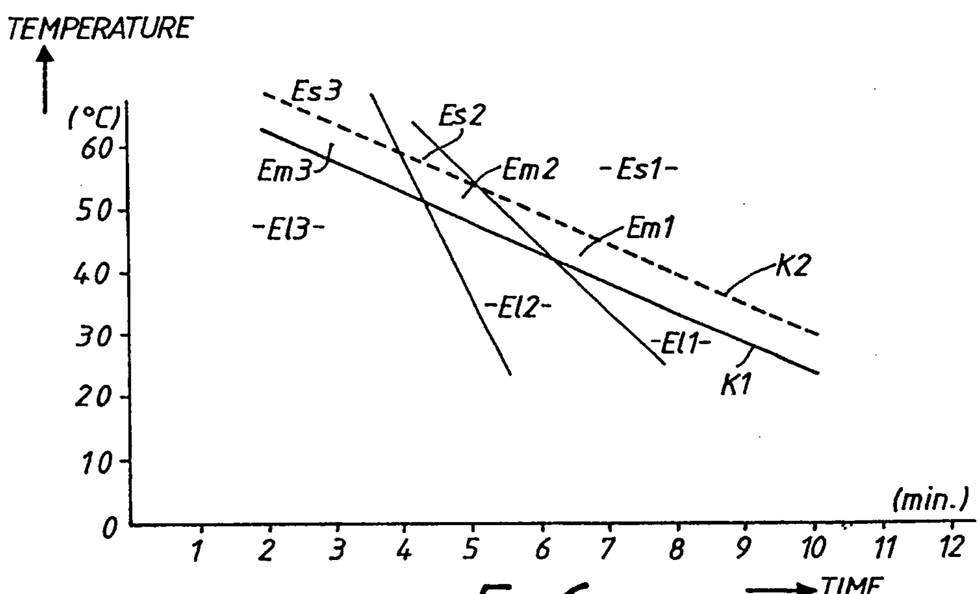


FIG.6.

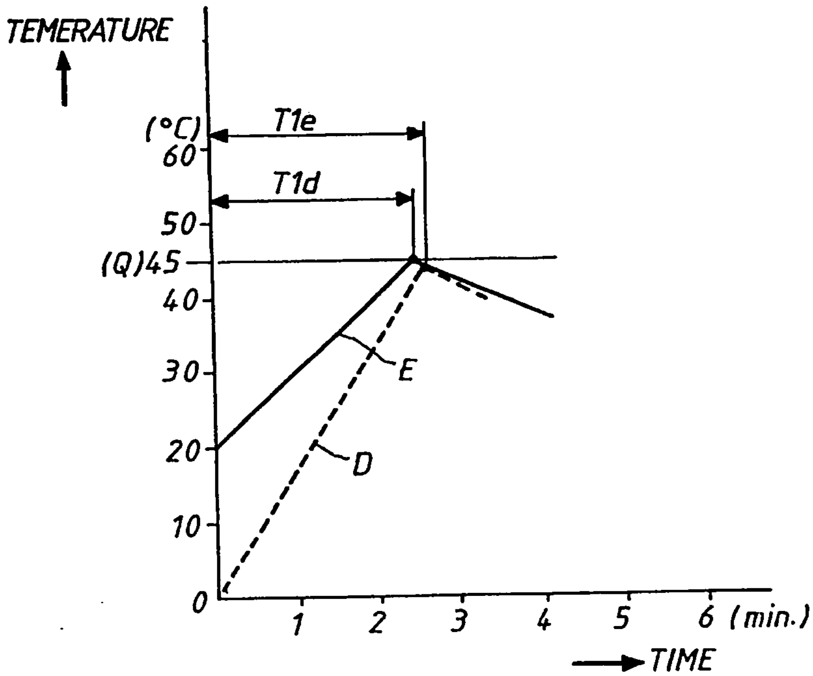

TEMERATURE
(°C)
60
50
(Q)45
40
30
20
10
0
T1e
T1d
E
D
1
2
3
4
5
6 (min.)
TIME

FIG. 7.

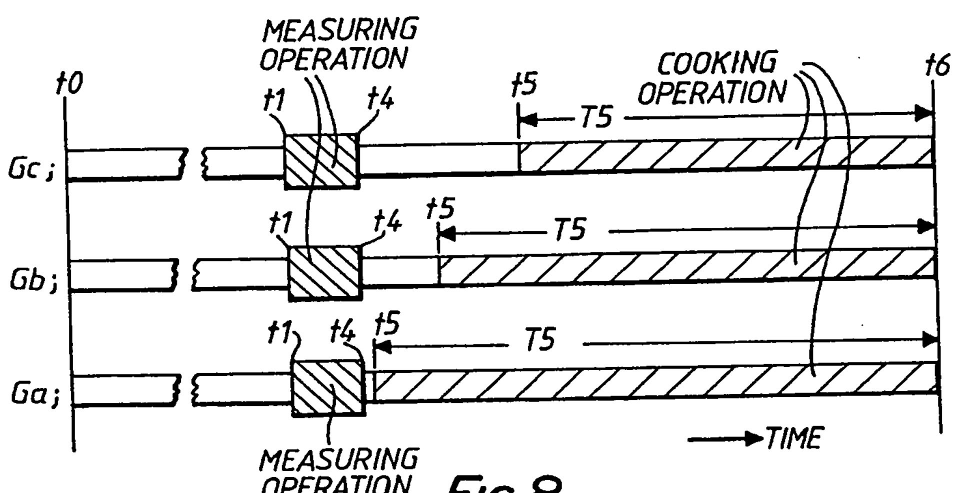

MEASURING OPERATION
COOKING OPERATION
t0
t1
t4
t5
t6
T5
Gc;
Gb;
Ga;
MEASURING OPERATION
TIME

FIG. 8.

SPECIFICATION

Method of operating cooking apparatus for cooking different quantities of food

This invention relates to a method of operating electric cooking apparatus in order to cook different quantities of food therein.

It is well known for electric cooking apparatus to have a built-in timer whereby operation of the apparatus to commence cooking is controlled by the timer. It is also known for some electric cooking apparatus to include a microcomputer which, in addition to serving as the timer, also calculates the time period from the setting time to the desired time at which cooking is to be completed. The microcomputer then subtracts the time required for the cooking operation, that is a specified cooking operation time set previously in the cooking control circuit, from the timer operation running period. Thus, the time for starting the cooking operation is calculated and, as a result, the cooking operation starts at the cooking operation starting time and finishes at the desired cooking completion time.

However, the cooking operation time depends to a large extent on the amount or volume of the food to be cooked, the cooking operation time being greater as the amount of food to be cooked is increased. In the known cooking apparatus referred to above, no account is taken of the quantity of food to be cooked when the cooking operation time is determined. Consequently, the operation time is usually determined on the basis of the maximum capacity of the cooking apparatus and this value is stored in the cooking control circuit. Consequently, when the quantity of food to be cooked in the apparatus is less than the maximum capacity, the correct cooking operation time is less than the value stored in the cooking control circuit and the food is cooked before the apparatus is switched off at the desired completion time.

The time taken to cook any quantity of food depends, to a certain extent, on the ambient temperature of the food, that is the cooking operation time is increased as the ambient temperature of the food is lowered. The known cooking apparatus referred to above does not take this into account.

It is an object of the present invention to operate cooking apparatus so that the cooking operation time is more accurately determined than heretofore.

According to the present invention, a method of operating cooking apparatus to cook food therein comprises the steps of heating a quantity of food material to a prescribed set temperature in the cooking apparatus; stopping the heating for a first predetermined period to allow the food material to lose heat; applying heat to the food material for a second prescribed period; detecting the actual temperature of the food material; measuring the time period elapsed until the actual temperature is detected; computing a value corresponding to the thermal capacity of the food material in the cooking apparatus from the detected temperature and the elapsed time period; and raising the temperature of the food material in the cooking apparatus to a prescribed cooking temperature for a period corresponding to the computed value.

In order that the invention may be more readily understood, it will now be described, by way of example only, with reference to the accompanying drawings, in which:—

Figure 1 is a cross-sectional side view showing the general construction of a conventional electric rice cooker;

Figure 2 is a temperature change characteristic diagram of a food material during measurement of the volume of the food material to be cooked contained in a cooking device according to the present invention;

Figure 3 is a time chart showing on/off operations of the heater in Fig. 1, according to the present invention;

Figure 4 is a temperature change characteristic diagram related to the initial temperature when the volume of a food material to be cooked is in the large capacity range of an electric rice cooker;

Figure 5 is a temperature change characteristic diagram related to the initial temperature when the volume of a food material to be cooked is in the small capacity range of an electric rice cooker;

Figure 6 is a diagram showing the relation between capacity ranges of an electric rice cooker and the initial temperature of the food material to be cooked;

Figure 7 is a temperature change characteristic diagram for explaining the method of the present invention; and

Figure 8 is a time chart showing an example of the cooking operation of an electric rice cooker in Fig. 1 according to the present invention.

Referring now to Fig. 1, a general construction of a typical electric rice cooker will be explained. The electric rice cooker 10 has a main body 11 and a lid 12. The lid 12 is mounted to the top end of the main body 11 through a hinge 13. The main body 11 has an outer vessel 14 formed in a cylindrical shape with a bottom and an inner vessel 15 mounted inside the outer vessel 14. The inner vessel 15 is also formed in a cylindrical shape with a bottom. The inner

vessel 15 is equipped with a heater 16 and a thermo-sensor unit 17 on its bottom. The inner vessel 15 is provided for receiving a pan 18. When the pan 18 is set in the inner vessel 15, the heater 16 faces a bottom section of the pan 18 and the thermo-sensor unit 17 contacts the bottom section of the pan 18. Thus, the heater 16 heats a food material 19 consisting of water 20 and rice 21 to be cooked in the pan 18. The thermo-sensor unit 17 detects the temperature of the pan 18. Here, the temperature of the pan 18 can be assumed to be almost the same as the temperature of the food material 19 in the pan 18.

The electric rice cooker 10 is further provided with a cooking controller 22. The cooking controller 22 comprises a microcomputer (not shown in the drawing) which has a current control function for the heater 16 in response to the thermo-sensor unit 17. The microcomputer also has a clock function so that the electric rice cooker 10 is provided with a timer operation for cooking.

The outline of the timer operation cooking will now be described. When a user sets a desired cooking completion time into the cooking controller 22 through an input device, such as a control panel 23, the cooking controller 22 subtracts the present time from the desired cooking completion time to obtain the total time to be elapsed until the cooking completion time. The cooking controller 22 then subtracts a prescribed cooking operation period from the total time. This and other prescribed cooking operation periods are previously set in a memory, such as a ROM (Read Only Memory), in the cooking controller 22 in accordance with capacity ranges, e.g., large (L), medium (M), and small (S) capacity ranges of the electric rice cooker 10. As a result, the cooking controller 22 calculates a time for starting the cooking operation preferable for the volume or thermal capacity of the food material 19 to be cooked. When a volume of the food material 19 to be cooked is measured as described later, one of the cooking operation start times corresponding to the volume of the food material 19 to be cooked is accessed from the memory. Then, the cooking controller 22 turns on the heater 16 at the specified cooking operation start time to perform the cooking operation for the food material 19 in the pan 18.

A method for measuring the volume of the food material 19 to be cooked according to the present invention will be described in detail below, in reference to Fig. 3. In this embodiment, it is assumed that three general capacity ranges L, M and S are defined for the electric rice cooker 10. A large capacity L ranges more than 70% of the maximum or full capacity F of the electric rice cooker 10 (i.e., $F \geqq L \geqq 0.7F$). A small capacity S ranges less than 30% of the full capacity F (i.e., $0.3F \geqq S > 0F$). A medium capacity M is between the large capacity L and the small capacity S (i.e., $0.7F > M > 0.3F$). It is also assumed that a measurement of the volume of the food material 19 to be cooked corresponds to any one of the three capacity ranges L, M and S.

In the measuring operation, the cooking controller 22 turns on the heater 16 at a time t1 as shown in Fig. 3, so that the heater 16 heats the food material 19 to be cooked in the pan 18. When the food material 19 reaches a prescribed set temperature Q, for example 45°C (the period required for the heating operation is taken as T1), the cooking controller 22 turns off the heater 16 at the end of the period T1 (the time at the end of the period T1 is taken as t2). Then the turn off state of the heater 16 is maintained for a first prescribed period T2, for example, two minutes (the time at the end of the period T2 is taken as t3). The food material 19 therefore radiates its heat during the heat radiation period T2. The cooking controller 22 again turns on the heater 16 at the time t3, i.e. the end of the heat radiation period T2. The cooking controller 22 maintains the turn on state of the heater 16 for a second prescribed period T3, for example, one minute (the time at the end of the period T3, i.e., the finishing time of the measurement operation is taken as t4). The cooking controller 22 then detects a final temperature R of the food material 19 through the thermo-sensor unit 17 at that time t4. The cooking controller 22 further counts the period T4 from the time t1, i.e. the measurement operation start time, to the time t4, i.e., the measurement operation finish time.

The temperature change of the food material 19 to be cooked in this case is described on the assumption that the temperature change takes any one of characteristic lines A, B and C in Fig. 2. In Fig. 2, times and periods are taken on the the X-coordinate from the measurement operation start time t1, while temperatures are taken on the Y-coordinate from 0°C. Lines K1 and K2 define three zones El, Em and Es corresponding to the three capacity ranges, L, M and S. When a coordinate (referred as final coordinate hereafter) given by the measurement operation finish time t4 and the final temperature R belongs to the zone El below the line K1, as shown by Pa in Fig. 2, the measurement operation determines that the volume of the food material 19 to be cooked is in the large capacity range L, as described later. When the final coordinate falls in the zone Es above the line K2, as shown by Pc in Fig. 2, the volume of the food material 19 to be cooked is in the small capacity range S. The final coordinate falls in the zone Em between the lines K1 and K2, as shown by Pb in Fig. 2. Therefore, the volume of the food material 19 to be cooked is in the medium capacity range M.

When assuming that the temperature change of the food material 19 to be cooked is shown by the characteristic line A in Fig. 2, the first heating period T1 in Fig. 3 is shown by time T1a. The final temperature at the measurement operation finishing time t4, which corresponds to the

final coordinate Pa on the temperature change characteristic line A, is shown by Ra and the required measurement operation period at that case is shown by T4a. From the fact that the final coordinate Pa of the temperature change characteristic line A belongs to the zone El, it is determined that the volume of the food material 19 to be cooked is in the large capacity range L. Also, when the temperature change of the food material 19 to be cooked is shown by the characteristic line B, the final coordinate Pb on the temperature change characteristic line B falls in the zone Em between the lines K1 and K2. As a result, it is determined that the volume of the food material 19 to be cooked is in the medium capacity range M. Further, when the temperature change of the food material 19 is shown by the characteristic line C, the final coordinate Pc on the temperature change characteristic line C falls in the zone Es above the line K2. As a result, it is determined that the volume of the food material 19 to be cooked is in the small capacity range S,

The lines K1 and K2 described above are specified as follows in relation to both the volume of the food material 19 to be cooked and its initial temperature (especially, the initial temperature of water). First, the line K1 for defining the zone El corresponding to the large capacity range L will be described in reference to Fig. 4. Fig. 4 shows the temperature change characteristic of the food material 19 to be cooked corresponds to the capacity 0.7F of the electric rice cooker 10. The volume 0.7F of the food material 19 to be cooked corresponds to the minimum level of the large capacity range L. Each temperature change characteristic line A0, A10, A20, A30 and A40 corresponds to the characteristic line when the initial temperature is 0°C, 10°C, 20°C, 30°C and 40°C, respectively. These temperature change characteristic lines A0, A10, A20, A30 and A40 show the temperature change obtained when performing the heating and the heat radiation of the food material 19 to be cooked according to the time chart shown in Fig. 3, that is, the method of the embodiment. As will be clear form the comparison of the temperature change characteristic lines A0, A10, A20, A30 and A40, each Y-coordinate of the final coordinates Pa0, Pa10, Pa20, Pa30 and Pa40, i.e., each of the final temperatures Ra0, Ra10, Ra20, Ra30 and Ra40 is relatively low, and each of the required measurement operation periods T4a0, T4a10, T4a20, T4a30 and T4a40 becomes relatively long. Then, the aforementioned line K1 is obtained by approximating a line linking the final coordinates Pa0, Pa10, Pa20, Pa30 and Pa40. First set of prescribed constants or parameters corresponding to the line K1 previously are set in the memory.

Next, the line K2 for defining the zone Es corresponding to the large capacity range S will be described in reference to Fig. 5. Fig. 5 shows the temperature change characteristic of the food material 19 to be cooked when the volume of the food material 19 to be cooked corresponds to the capacity 0.3F of the electric rice cooker 10. The volume 0.3F of the food material 19 to be cooked corresponds to the maximum level of the small capacity range S. Each temperature change characteristic line C0, C10, C20, C30 and C40 corresponds to the characteristic line when the initial temperature is 0°C, 10°C, 20°C, 30°C and 40°C, respectively. These temperature change characteristic lines C0, C10, C20, C30 and C40 show the temperature change obtained when performing the heating and the heat radiation of the food material 19 to be cooked according to the time chart shown in Fig. 3, that is, the method of the embodiment. As will be clear from the comparison of the temperature change characteristic lines C0, C10, C20, C30 and C40, each Y-coordinate of the final coordinates Pc0, Pc10, Pc20, Pc30 and Pc40, i.e., each of the final temperatures Rc0, Rc10, Rc20, Rc30 and Rc40 is relatively high, and each of the required measurement operation periods T4c0, T4c10, T4c0, T4c30 and T4c40 becomes relatively short. Then, the aforementioned line K2 is obtained by approximating to a line linking the final coordinates Pc0, Pc10, Pc20, Pc30 and Pc40. Second set of prescribed constants or parameters corresponding to the line K2 previously are set in the memory.

When comparing the second line K2 with the first line K1, the second line K2 is shifted in the direction where the final temperatures R are raised, and the required measurement operation periods Ts are prolonged more than those of the first line K1. As will be clear from the comparisons of the final temperatures R and the required measurement operation periods T4 between the lines K1 and K2, it is shown that in the zone El on the side where the final temperatures R are lowered and the required measurement operation periods Ts are shortened in comparison to those of the first line K1, the volume of the food material 19 to be cooked is in the large capacity range L. In the zone Es on the side where the final temperatures R are raised and the required measurement operation periods T4 are prolonged in comparison to those of the second line K2, the volume of the food material 19 to be cooked is in the small capacity range S.

In Fig. 6, a division of the initial temperature into three stages is shown, in addition to the division of the capacity range. In Fig. 6, subzones with additive letters "3", "2" and "1" added to the letters El, Em and Es, correspond to the initial temperatures of "high", "medium" and "low", respectively.

Referring now to Fig. 7, another, but presently considered less desirable method for measuring the volume of the food material 19 to be cooked will be described. Instead of the above

method, the volume of the food material 19 to be cooked and its thermal capacity can be determined by detecting the period T1 required to heat the food material 19 to be cooked up to the prescribed set temperature Q, and measuring the volume of the food material 19 to be cooked on the basis of the prescribed set temperature Q. In this case, however, as will be clear from Fig. 7, when the volume of the food material 19 to be cooked is in the small capacity range S and the initial temperature is in "low" temperature stage, the temperature change of the food material 19 to be cooked is given by the characteristic line D. In this case, the first heating operation period T1 becomes T1d as shown in Fig. 7. When the volume of the food material 19 to be cooked is in the medium capacity range M and the initial temperature is in the "medium" temperature stage, the temperature change of the food material 19 to be cooked is given by the characteristic line E. In this case, the first heating operation period T1 becomes T1e as shown in Fig. 7. As clearly seen from Fig. 7, these two first heating operation periods T1d and T1e become closer to each other, or become substantially equal. As a result, in this method, the volume of the food material 19 to be cooked may be erroneously measured. Such an error also can be caused between the situations where the volume of the food material 19 to be cooked is in the medium capacity range M and the initial temperature is in the "medium" temperature stage, as shown by the characteristic line E, and the case where the volume of the food material 19 to be cooked is in the large capacity range L and the initial temperature is in the "high" temperature stage. That is, the variations of the initial temperature cause error in measuring the volume of the food material.

In the embodiment according to the present invention, as described by referring to Fig. 3, the food material 19 to be cooked is heated up to the prescribed set temperature Q. As a result, the initial temperature of the food material 19 to be cooked is corrected to the same set temperature Q. In this case, the required first heating operation period T1 is determined by the degree of the initial temperature of the food material 19 to be cooked. After that, the heat of the food material 19 to be cooked is radiated for the prescribed heat radiation period T2. The temperature resulting from the heat radiation at the end of the heat radiation period T2 (for example, Q on the characteristic line A in Fig. 2) is determined with relation to the ambient temperature. In other words, the temperature Q due to the heat radiation is determined by the ambient temperature which determines the initial temperature of the food material 19 to be cooked. After the heat radiation, by heating the food material 19 to be cooked again for the prescribed heating operation period T3, the final temperature R is detected through the thermo-sensor unit 17 at the measurement operation finishing time t4 when the second heating operation period T3 is elapsed. Also the required measurement operation period T4 between the times t1 and t4 is calculated. The amount or volume of the food material 19 to be cooked is measured on the basis of the final temperature R and the required measurement operation period T4 (e.g., the final coordinate Pa of the temperature change characteristic line A in Fig. 2).

According to this embodiment, therefore, the volume of the food material 19 to be cooked can be measured accurately without influence from variations of the initial temperature of the food material 19 to be cooked.

The relation between the final temperatures R and the required measurement operation periods T4 specified by the first and second capacity zone defining lines K1 and K2 is previously set in the memory of the cooking controller 22 of the electric rice cooker 10 as preset data. When a user sets a desired cooking completion time t6 to the timer function of the cooking controller 22 through the control panel 23, the measurement operation, as described above, is carried out at the time t1 after a specified period T0 from the timer setting time t0 (see Fig. 8), and the previously stored data for calculating the volume of the food material 19 to be cooked, such as data on the zone defining lines K1 and K2, is accessed. Then, the cooking controller 22 measures the volume of the food material 19 to be cooked, on the basis of the detected final temperature R and the required measurement operation periods T4. The cooking controller 22 accesses the proper cooking operation period data from the memory, in accordance with the capacity range L, M or S corresponding to the volume of the food material 19 to be cooked. Then the cooking controller 22 starts the cooking operation for the food material 19 to be cooked at the time t1 well before a start of a required cooking operation period T5 in correspondence with the capacity ranges L, M and S of the cooking material 19 to be cooked. In this case, the cooking operation period T5 is set according to the following table, on the basis of the final temperature R and the required measurement operation period T4. These parameters determine whether the final coordinate P of the temperature change characteristic line corresponds to the zone El3 to El1, Em3 to Em1, or Es3 to Es1 (see Fig. 6).

Zone	Cooking Operation Period
El1	60 minutes
El2, Em1	55 minutes
El3, Em2, Es1	50 minutes
Em3, Es2	45 minutes
Es3	40 minutes

Accordingly, the cooking operation start time t5 is calculated so as to correspond to the volume of thermal capacity of the food material 19 to be cooked. Fig. 8 shows examples of the time charts according to the present invention. Graph Ga shows the time chart when the volume of the food material 19 to be cooked is in the large capacity L (for example, the zone El1 in Fig. 6). Graph Gb shows the time chart when the volume of the food material 19 to be cooked is in the medium capacity M (for example, the zone Em2 in Fig. 6). Graph Gc shows the time chart when the volume of the food material 19 to be cooked is in the small capacity S (for example, the zone Es2 in Fig. 6). As will be clear from Fig. 8, the cooking operations in the respective capacity ranges are completed at the same desired cooking completion time T6, irrespective of the volume of the food material 19 to be cooked in the electric rice cooker 10.

In the embodiment described above, a food material to be cooked, such as rice and water, is illustrated. However, any other food material to be cooked, such as soybeans and water may be similarly measured and cooked according to the present invention.

CLAIMS

1. A method of operating cooking apparatus to cook food therein, the method comprising the steps of:

heating a quantity of food material (19) to a prescribed set temperature (Q) in the cooking apparatus (10);

stopping the heating for a first predetermined period (T2) to allow the food material (19) to lose heat;

applying heat to the food material (19) for a second prescribed period (T3);

detecting the actual temperature (R) of the food material (19);

measuring the time period (T4) elapsed until the actual temperature is detected;

computing a value corresponding to the thermal capacity of the food material (19) in the cooking apparatus (10) from the detected temperature (R) and the elapsed time period (T4); and

raising the temperature of the food material (19) in the cooking apparatus (10) to a prescribed cooking temperature for a period (T5) corresponding to the computed value.

2. The method of claim 1, including the step of manually entering a desired cooking completion time (t6) into an input device (23) of the cooking apparatus (10) and wherein the step of raising the temperature includes the step of automatically calculating the commencement of the cooking operation period (T5) from the desired cooking completion time (t6).

3. The method of claim 1 or 2, wherein the computing step includes the step of reading prescribed stored constants from a memory and the step of comparing the detected temperature (R) and the elapsed period (T4) with the corresponding constants.

4. The method of claim 3, wherein the comparing step includes the step of generating resultant parameters from the constants, each parameter defining a general capacity level of the cooking apparatus (10) into zones (El, Em, Es), and the step of judging any of the zones (El, Em, Es) corresponding to the computed value based on the resultant parameters.

5. A method of operating cooking apparatus to cook a quantity of food therein substantially as hereinbefore described with reference to the accompanying drawings.

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